Introduction - Chemistry

The following released test questions are taken from the Chemistry Standards Test. This test is one of the California Standards Tests administered as part of the Standardized Testing and Reporting (STAR) Program under policies set by the State Board of Education.

All questions on the California Standards Tests are evaluated by committees of content experts, including teachers and administrators, to ensure their appropriateness for measuring the California academic content standards in Chemistry. In addition to content, all items are reviewed and approved to ensure their adherence to the principles of fairness and to ensure no bias exists with respect to characteristics such as gender, ethnicity, and language.

This document contains released test questions from the California Standards Test forms in 2003 and 2004. First on the pages that follow are lists of the standards assessed on the Chemistry Test. Next are released test questions. Following the questions is a table that gives the correct answer for each question, the content standard that each question is measuring, and the year each question last appeared on the test. Reference sheets, provided for students taking the test, are also included as they are necessary in answering some of the questions. It should be noted that asterisked (*) standards found in the *Science Content Standards for California Public Schools, Kindergarten through Grade 12,* are not assessed on the California Standards Tests in Science and, therefore, are not represented in these released test questions.

The following table lists each reporting cluster, the number of items that appear on the exam, and the number of released test questions that appear in this document. The released test questions for Biology, Chemistry, Earth Science, and Physics are the same test questions found in different combinations on the Integrated Science 1, 2, 3, and 4 tests.

Chemistry — Released Test Questions

REPORTING CLUSTER	NUMBER OF QUESTIONS ON EXAM	NUMBER OF RELEASED TEST QUESTIONS
Investigation and Experimentation (Standards: CHIE1. a-n)	6	3
Atomic and Molecular Structure *Atomic and Molecular Structure* (Standards: CH1. a-e) *Nuclear Processes* (Standards: CH11. a-e)	8	6
Chemical Bonds, Biochemistry *Chemical Bonds* (Standards: CH2. a-e) *Organic Chemistry and Biochemistry* (Standards: CH10. a-c)	9	4
Kinetics, Thermodynamics *Gases and Their Properties* (Standards: CH4. a-f) *Solutions* (Standards: CH6. a-d) *Chemical Thermodynamics* (Standards: CH7. a-d)	14	10
Chemical Reactions *Acids and Bases* (Standards: CH5. a-d) *Reaction Rates* (Standards: CH8. a-c) *Chemical Equilibrium* (Standards: CH9. a-b)	13	4
Conservation of Matter and Stoichiometry (Standards: CH3. a-e)	10	3
TOTAL	60	30

In selecting test questions for release, three criteria are used: (1) the questions adequately cover a selection of the academic content standards assessed on the Chemistry Test; (2) the questions demonstrate a range of difficulty; and (3) the questions present a variety of ways standards can be assessed. These released test questions do not reflect all of the ways the standards may be assessed. Released test questions will not appear on future tests.

For more information about the California Standards Tests, visit the California Department of Education's Web site at http://www.cde.ca.gov/ta/tg/sr/resources.asp.

THE INVESTIGATION AND EXPERIMENTATION REPORTING CLUSTER

The following 14 California content standards are included in the Investigation and Experimentation reporting cluster and are represented in this booklet by three test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Investigation and Experimentation	
CHIE1.	**Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other five reporting clusters, students should develop their own questions and perform investigations. Students will:**
CHIE1. a.	Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
CHIE1. b.	Identify and communicate sources of unavoidable experimental error.
CHIE1. c.	Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
CHIE1. d.	Formulate explanations by using logic and evidence.
CHIE1. e.	Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
CHIE1. f.	Distinguish between hypothesis and theory as scientific terms.
CHIE1. g.	Recognize the usefulness and limitations of models and theories as scientific representations of reality.
CHIE1. h.	Read and interpret topographic and geologic maps.
CHIE1. i.	Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
CHIE1. j.	Recognize the issues of statistical variability and the need for controlled tests.
CHIE1. k.	Recognize the cumulative nature of scientific evidence.
CHIE1. l.	Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
CHIE1. m.	Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
CHIE1. n.	Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).

THE ATOMIC AND MOLECULAR STRUCTURE REPORTING CLUSTER

The following 10 California content standards are included in the Atomic and Molecular Structure reporting cluster and are represented in this booklet by six test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Atomic and Molecular Structure	
CH1.	**The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:**
CH1. a.	*Students know* how to relate the position of an element in the periodic table to its atomic number and atomic mass.
CH1. b.	*Students know* how to use the periodic table to identify metals, semimetals, non-metals, and halogens.
CH1. c.	*Students know* how to use the periodic table to identify alkali metals, alkaline earth metals and transition metals, trends in ionization energy, electronegativity, and the relative sizes of ions and atoms.
CH1. d.	*Students know* how to use the periodic table to determine the number of electrons available for bonding.
CH1. e.	*Students know* the nucleus of the atom is much smaller than the atom yet contains most of its mass.
Nuclear Processes	
CH11.	**Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:**
CH11. a.	*Students know* protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.
CH11. b.	*Students know* the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E = mc^2$) is small but significant in nuclear reactions.
CH11. c.	*Students know* some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
CH11. d.	*Students know* the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
CH11. e.	*Students know* alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.

THE CHEMICAL BONDS, BIOCHEMISTRY REPORTING CLUSTER

The following eight California content standards are included in the Chemical Bonds, Biochemistry reporting cluster and are represented in this booklet by four test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Chemical Bonds	
CH2.	**Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules. As a basis for understanding this concept:**
CH2. a.	*Students know* atoms combine to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.
CH2. b.	*Students know* chemical bonds between atoms in molecules such as H_2, CH_4, NH_3, H_2CCH_2, N_2, Cl_2 and many large biological molecules are covalent.
CH2. c.	*Students know* salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.
CH2. d.	*Students know* the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.
CH2. e.	*Students know* how to draw Lewis dot structures.
Organic Chemistry and Biochemistry	
CH10.	**The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life. As a basis for understanding this concept:**
CH10. a.	*Students know* large molecules (polymers), such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
CH10. b.	*Students know* the bonding characteristics of carbon that result in the formation of a large variety of structures ranging from simple hydrocarbons to complex polymers and biological molecules.
CH10. c.	*Students know* amino acids are the building blocks of proteins.

THE KINETICS, THERMODYNAMICS REPORTING CLUSTER

The following 14 California content standards are included in the Kinetics, Thermodynamics reporting cluster and are represented in this booklet by 10 test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Gases and Their Properties	
CH4.	**The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:**
CH4. a.	*Students know* the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
CH4. b.	*Students know* the random motion of molecules explains the diffusion of gases.
CH4. c.	*Students know* how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.
CH4. d.	*Students know* the values and meanings of standard temperature and pressure (STP).
CH4. e.	*Students know* how to convert between the Celsius and Kelvin temperature scales.
CH4. f.	*Students know* there is no temperature lower than 0 Kelvin.
Solutions	
CH6.	**Solutions are homogenous mixtures of two or more substances. As a basis for understanding this concept:**
CH6. a.	*Students know* the definitions of *solute* and *solvent*.
CH6. b.	*Students know* how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
CH6. c.	*Students know* temperature, pressure, and surface area affect the dissolving process.
CH6. d.	*Students know* how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
Chemical Thermodynamics	
CH7.	**Energy is exchanged or transformed in all chemical reactions and physical changes of matter. As a basis for understanding this concept:**
CH7. a.	*Students know* how to describe temperature and heat flow in terms of the motion of molecules (or atoms).
CH7. b.	*Students know* chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.
CH7. c.	*Students know* energy is released when a material condenses or freezes and is absorbed when a material evaporates or melts.
CH7. d.	*Students know* how to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.

THE CHEMICAL REACTIONS REPORTING CLUSTER

The following nine California content standards are included in the Chemical Reactions reporting cluster and are represented in this booklet by four test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Acids and Bases	
CH5.	**Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:**
CH5. a.	*Students know* the observable properties of acids, bases, and salt solutions.
CH5. b.	*Students know* acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
CH5. c.	*Students know* strong acids and bases fully dissociate and weak acids and bases partially dissociate.
CH5. d.	*Students know* how to use the pH scale to characterize acid and base solutions.
Reaction Rates	
CH8.	**Chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules. As a basis for understanding this concept:**
CH8. a.	*Students know* the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
CH8. b.	*Students know* how reaction rates depend on such factors as concentration, temperature, and pressure.
CH8. c.	*Students know* the role a catalyst plays in increasing the reaction rate.
Chemical Equilibrium	
CH9.	**Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:**
CH9. a.	*Students know* how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure.
CH9. b.	*Students know* equilibrium is established when forward and reverse reaction rates are equal.

THE CONSERVATION OF MATTER AND STOICHIOMETRY REPORTING CLUSTER

The following five California content standards are included in the Conservation of Matter and Stoichiometry reporting cluster and are represented in this booklet by three test questions. These questions represent only some ways in which these standards may be assessed on the California Chemistry Standards Test.

CALIFORNIA CONTENT STANDARDS IN THIS REPORTING CLUSTER

Conservation of Matter and Stoichiometry	
CH3.	**The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:**
CH3. a.	*Students know* how to describe chemical reactions by writing balanced equations.
CH3. b.	*Students know* the quantity *one mole* is set by defining one mole of carbon 12 atoms to have a mass of exactly 12 grams.
CH3. c.	*Students know* one mole equals 6.02×10^{23} particles (atoms or molecules).
CH3. d.	*Students know* how to determine the molar mass of a molecule from its chemical formula and a table of atomic masses and how to convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.
CH3. e.	*Students know* how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.

1 **Electrical fires cannot be safely put out by dousing them with water. However, fire extinguishers that spray solid carbon dioxide on the fire work very effectively. This method works because carbon dioxide**

A displaces the oxygen.

B renders the fire's fuel non-flammable.

C forms water vapor.

D blows the fire out with strong wind currents.

2 **In order to advance to the level of a theory, a hypothesis should be**

A obviously accepted by most people.

B a fully functional experiment.

C in alignment with past theories.

D repeatedly confirmed by experimentation.

3 **When a metal is heated in a flame, the flame has a distinctive color. This information was eventually extended to the study of stars because**

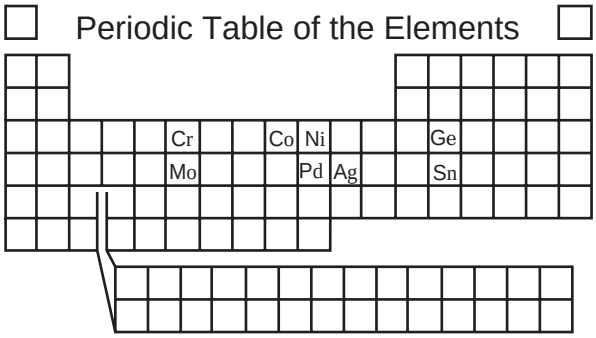
A the color spectra of stars indicate which elements are present.

B a red shift in star color indicates stars are moving away.

C star color indicates absolute distance.

D it allows the observer to determine the size of stars.

4



Which of the following ordered pairs of elements shows an increase in atomic number but a decrease in average atomic mass?

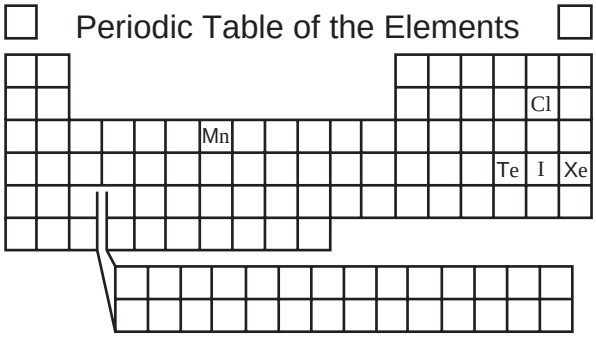
A Ag to Pd

B Co to Ni

C Ge to Sn

D Cr to Mo

5



Iodine would have chemical properties *most* like

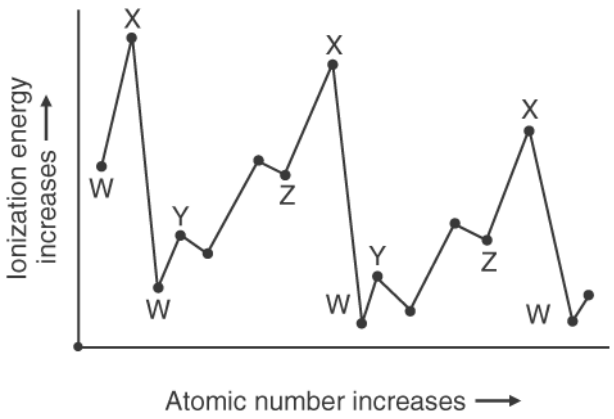
A manganese (Mn).

B tellurium (Te).

C chlorine (Cl).

D xenon (Xe).

6



The chart above shows the relationship between the first ionization energy and the increase in atomic number. The letter on the chart for the alkali family of elements is

A W.

B X.

C Y.

D Z.

7 **Which of the following atoms has six valence electrons?**

A magnesium (Mg)

B silicon (Si)

C sulfur (S)

D argon (Ar)

8 **Which statement *best* describes the density of an atom's nucleus?**

A The nucleus occupies most of the atom's volume but contains little of its mass.

B The nucleus occupies very little of the atom's volume and contains little of its mass.

C The nucleus occupies most of the atom's volume and contains most of its mass.

D The nucleus occupies very little of the atom's volume but contains most of its mass.

9 **A 2-cm-thick piece of cardboard placed over a radiation source would be *most* effective in protecting against which type of radiation?**

A alpha

B beta

C gamma

D x-ray

10 **The reason salt crystals, such as KCl, hold together so well is because the cations are strongly attracted to**

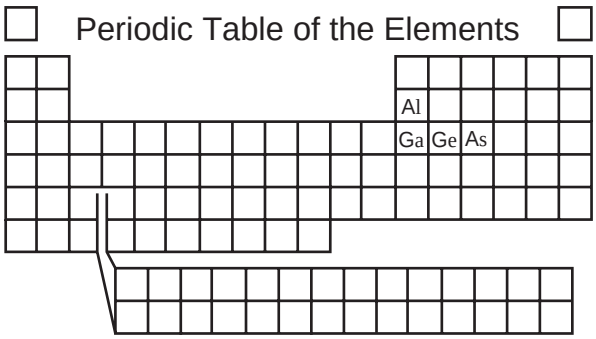
A neighboring cations.

B the protons in the neighboring nucleus.

C free electrons in the crystals.

D neighboring anions.

11



Which of the following elements has the same Lewis dot structure as silicon?

A germanium (Ge)

B aluminum (Al)

C arsenic (As)

D gallium (Ga)

12 **Which substance is made up of many monomers joined together in long chains?**

A salt

B protein

C ethanol

D propane

13 **Proteins are large macromolecules composed of thousands of subunits. The structure of the protein depends on the sequence of**

A lipids.

B monosaccharides.

C amino acids.

D nucleosides.

14 **When someone standing at one end of a large room opens a bottle of vinegar, it may take several minutes for a person at the other end to smell it. Gas molecules at room temperature move at very high velocities, so what is responsible for the delay in detection of the vinegar?**

A the increase in the airspace occupied by vinegar molecules

B the chemical reaction with nerves, which is slower than other sensory processes

C attractive forces between the air and vinegar molecules

D random collisions between the air and vinegar molecules

15 **The volume of 400 mL of chlorine gas at 400 mm Hg is decreased to 200 mL at constant temperature. What is the new gas pressure?**

A 400 mm Hg

B 300 mm Hg

C 800 mm Hg

D 650 mm Hg

16 **Standard temperature and pressure (STP) are defined as**

A 0 ºC and 1.0 atm pressure.

B 0 ºC and 273 mm Hg pressure.

C 0 K and 1.0 atm pressure.

D 0 K and 760 mm Hg pressure.

17 **What is the equivalent of 423 kelvin in degrees Celsius?**

A $^{-}$223 ºC

B $^{-}$23 ºC

C 150 ºC

D 696 ºC

18 **If the attractive forces among solid particles are less than the attractive forces between the solid and a liquid, the solid will**

A probably form a new precipitate as its crystal lattice is broken and re-formed.

B be unaffected because attractive forces within the crystal lattice are too strong for the dissolution to occur.

C begin the process of melting to form a liquid.

D dissolve as particles are pulled away from the crystal lattice by the liquid molecules.

19 **If the solubility of NaCl at 25 ºC is 36.2 g/100 g H_2O, what mass of NaCl can be dissolved in 50.0 g of H_2O?**

A 18.1 g

B 36.2 g

C 72.4 g

D 86.2 g

20 **How many moles of HNO_3 are needed to prepare 5.0 liters of a 2.0 M solution of HNO_3?**

A 2.5

B 5

C 10

D 20

21 **The random molecular motion of a substance is greatest when the substance is**

A condensed.

B a liquid.

C frozen.

D a gas.

22 **The boiling point of liquid nitrogen is 77 kelvin. It is observed that ice forms at the opening of a container of liquid nitrogen. The *best* explanation for this observation is**

A water at zero degrees Celsius is colder than liquid nitrogen and freezes.

B the nitrogen boils and then cools to form a solid at the opening of the container.

C water trapped in the liquid nitrogen escapes and freezes.

D the water vapor in the air over the opening of the liquid nitrogen freezes out.

23 **The specific heat of copper is about 0.4 joules/gram ºC. How much heat is needed to change the temperature of a 30-gram sample of copper from 20.0 ºC to 60.0 ºC?**

A 1000 J

B 720 J

C 480 J

D 240 J

24 **Equal volumes of 1 molar hydrochloric acid (HCl) and 1 molar sodium hydroxide base (NaOH) are mixed. After mixing, the solution will be**

A strongly acidic.

B weakly acidic.

C nearly neutral.

D weakly basic.

25 **A catalyst can speed up the rate of a given chemical reaction by**

A increasing the equilibrium constant in favor of products.

B lowering the activation energy required for the reaction to occur.

C raising the temperature at which the reaction occurs.

D increasing the pressure of reactants, thus favoring products.

26 **When a reaction is at equilibrium and more reactant is added, which of the following changes is the immediate result?**

A The reverse reaction rate remains the same.

B The forward reaction rate increases.

C The reverse reaction rate decreases.

D The forward reaction rate remains the same.

27 **In which of the following reactions involving gases would the forward reaction be favored by an increase in pressure?**

A $A + B \rightleftharpoons AB$

B $A + B \rightleftharpoons C + D$

C $2A + B \rightleftharpoons C + 2D$

D $AC \rightleftharpoons A + C$

28

$$C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$$

This chemical equation represents the combustion of propane. When correctly balanced, the coefficient for water is

A 2.

B 4.

C 8.

D 16.

29 **How many moles of carbon-12 are contained in exactly 6 grams of carbon-12?**

A 0.5 mole

B 2.0 moles

C 3.01×10^{23} moles

D 6.02×10^{23} moles

30 **How many moles of CH_4 are contained in 96.0 grams of CH_4?**

A 3.00 moles

B 6.00 moles

C 12.0 moles

D 16.0 moles

Question Number	Correct Answer	Standard	Year of Test
1	*A*	CHIE1.D	2004
2	*D*	CHIE1.F	2004
3	*A*	CHIE1.K	2003
4	*B*	CH1.A	2004
5	*C*	CH1.B	2004
6	*A*	CH1.C	2003
7	*C*	CH1.D	2003
8	*D*	CH1.E	2004
9	*A*	CH11.E	2003
10	*D*	CH2.C	2004
11	*A*	CH2.E	2003
12	*B*	CH10.A	2003
13	*C*	CH10.C	2004
14	*D*	CH4.B	2004
15	*C*	CH4.C	2003
16	*A*	CH4.D	2004
17	*C*	CH4.E	2003
18	*D*	CH6.B	2004
19	*A*	CH6.D	2003
20	*C*	CH6.D	2004
21	*D*	CH7.A	2003
22	*D*	CH7.C	2004
23	*C*	CH7.D	2003
24	*C*	CH5.A	2003
25	*B*	CH8.C	2003
26	*B*	CH9.A	2003
27	*A*	CH9.A	2004
28	*B*	CH3.A	2004
29	*A*	CH3.B	2004
30	*B*	CH3.D	2003

Periodic Table of the Elements

Chemistry Reference Sheet

California Standards Test

	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** Hydrogen 1.01	2 2A																2 **He** Helium 4.00
2	3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.87	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)									

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.

Chemistry Reference Sheet

Formulas

Ideal Gas Law: $PV = nRT$

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Pressure Formula: $P = \frac{F}{A}$

Mass-Energy Formula: $E = mc^2$

Calorimetric Formulas –

No Phase Change: $Q = m(\Delta T)C_p$

Latent Heat of Fusion: $Q = m\Delta H_{fus}$

Latent Heat of Vaporization: $Q = m\Delta H_{vap}$

Constants

Volume of Ideal Gas at STP: $22.4 \frac{L}{mol}$

Speed of Light in a Vacuum: $c = 3.00 \times 10^8 \frac{m}{s}$

Specific Heat of Water: $C_p(H_2O) = 1.00 \frac{cal}{(g\ °C)} = 4.18 \frac{J}{(g\ °C)}$

Latent Heat of Fusion of Water: $\Delta H_{fus}(H_2O) = 80 \frac{cal}{g} = 334 \frac{J}{g}$

Latent Heat of Vaporization of Water: $\Delta H_{vap}(H_2O) = 540 \frac{cal}{g} = 2260 \frac{J}{g}$

Unit Conversions

Calorie-Joule Conversion: 1 cal = 4.184 J

Absolute Temperature Conversion: K = °C + 273

Pressure Conversions: 1 atm = 760 mm Hg = 760 Torr = 101.325 kPa = $14.7 \frac{lbs.}{in.^2}$ = 29.92 in. Hg